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Effect of Animal Grouping on Feeding Behavior and Intake of Dairy Cattle[1]

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ABSTRACT

Although data are scarce, it is clear that grouping strategy can have a significant impact on the feeding behavior and feed intake of dairy cattle. Feed intake is controlled by ruminoreticular fill and physiological mechanisms, but grouping is a component of the cow's feeding environment that can modulate intake as a result of its impact on cow comfort, competition for feed and other resources, and herd health. Social dominance and competition for feed impact feeding behavior and proper grouping strategy will minimize the negative impact of excessive competition on intake and enhance beneficial effects of group feeding such as social facilitation. Primiparous cows benefit from separate grouping from older animals by increased intake and productivity. Bunk space, accessibility of feed, and type of feeding system must be considered when determining the optimal group size. There appears to be no problem with large (>200 cows) groups of cows per se, but management decisions such as overcrowding with insufficient head gates or manger space play a role in determining cow well-being and feeding behavior. Research with group sizes larger than 400 cows needs to evaluate productivity, feeding and other behavior, and animal well-being. Significant overcrowding appears to reduce feeding activity, alter resting behavior, and decrease rumination activity. Negative social consequences of moving cows between groups last 3 to 7 d. Although the effect of grouping on feeding behavior remains largely unquantitated at this point, the effect is potentially large and requires further research to describe the impact of cow dynamics within a group on feed intake.
(**Key words**: dairy cows, behavior, feed intake, eating)

INTRODUCTION

Feeding is the predominant behavior of ruminants, as illustrated by the observation that feeding activity has priority over rumination whenever the causal factors of the two activities conflict (Metz, 1975). Feed intake is the major factor influencing milk production and body condition change during lactation. Consequently, grouping strategy and subsequent group feeding behavior that influence DMI potentially have a tremendous impact on cow productivity, animal well-being, herd health, and farm profitability. The design of the feeding system, feeding management, and dietary formulations must recognize the dynamic nature of dairy cow psychology and physiology, nutrient requirements, and variability in feedstuff composition (Sniffen et al., 1993). Improperly grouping dairy cows may perturb their normal behavioral routines and time budgets. In essence, dairy cows spend 3 to 5 h/d eating, consuming 9 to 14 meals per day. In addition, they ruminate 7 to 10 h/d, spend approximately 30 min/d drinking, 2 to 3 h/d being milked, and require approximately 10 h/d of lying and (or) resting time (Grant and Albright, 2000). Management decisions on a dairy must not interfere with the cow's ability to perform these activities which comprise her daily routines. Grouping should not only minimize negative social interactions and encourage positive interactions, but proper grouping strategy will also decrease within-group variation and increase across-group variation. A more homogeneous group of cows makes proper ration formulation easier and also decreases nutrient excretion, thus reducing the impact on the environment and land use (St-Pierre and Thraen, 1999).

Although feeding behavior and DMI are controlled by ruminoreticular fill and chemostatic mechanisms, feed intake is modulated by management factors such as grouping strategy, feeding and housing facilities, and social interactions that occur throughout the day. Factors that modulate feeding behavior can be optimized to promote intense feeding activity and maximum DMI. Researchers at Michigan State University (Dado and Allen, 1994) characterized this intense feeding behavior in higher producing, older cows that consumed more feed, ate larger meals more quickly, ruminated longer and more efficiently, and drank more water than lower producing, and typically younger cows. Well-designed management systems accommodate normal feeding behavior to improve animal movement, comfort, and well-being (Grant and Albright, 2000). For example, accessibility of feed during times of the day when cows want to eat, such as when leaving the milking parlor, promotes greater feeding activity at the feedbunk (Menzi and Chase, 1994). Likewise, proper animal grouping strategies within herds reduce competition for feed at the bunk or manger and improve feed intake (Grant and Albright, 2000).

This paper will focus on the relationships among cow grouping, group size, bunk space and competition for feed, facility design, cow behavior, and age of cow. Although grouping strategy has many effects on dairy herd performance, this paper will emphasize the impact on feeding behavior and DMI.

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FACTORS INFLUENCING GROUP SIZE AND NUMBER OF GROUPS

Dividing the milking herd into groups often allows for better herd management. Dairy cows have been managed traditionally in groups of 40 to 100 cows (Albright, 1978). Proper grouping can simplify cow movement, facilitate observation of cows, and allow rations to more closely match the requirements of each individual cow within the group. Several factors interact to determine the optimal group size of cows on any dairy herd. These factors include 1) feedbunk space and competition for feed, water, and free stalls, 2) social interactions among cows and how they are affected by group size, 3) space available to the cow, 4) size of holding area and capacity of milking parlor, 5) animal body size and age, 6) body condition, 7) DIM, 8) stall size and equity, and 9) adequacy of ventilation. Stall equity means that every stall is equally comfortable and likely to be used by a cow. Rapid movement to and from the milking parlor, continuous availability of palatable feed, fenceline feeding rather than elevated feedbunks with cows eating around them (Albright, 1993), and relatively homogeneous cow characteristics can allow greater animal housing density without apparent stress problems (Shultz, 1992).

The upper limit of group size is dictated practically by parlor size and time spent in the holding pen. Cows should spend no longer than 45 min to 1 h waiting to be milked with 2 or 3 times per day milking. A good generalization for maximum group size in herds with herringbone and parallel parlors is 4.5× the parlor size (Smith et al., 2000). For example, groups for a double-10 parlor should contain 90 cows or fewer. Realistically, management of feeding and housing facilities will determine how large a group can be within the constraint imposed by parlor size. Limited time in the holding area enhances cow comfort and well-being because it minimizes crowding, time away from feed, water, and resting areas.

A survey of the highest producing herds in the United States revealed that over 67% of producers used a TMR feeding system, and that these producers averaged 2.9 groups of cows that were fed 2.7 times daily (Jordan and Fourdraine, 1993). Several researchers have examined various grouping strategies and suggested that cows might best be grouped by nutrient requirements (Sniffen et al., 1993). Williams and Oltenacu (1992) compared seven grouping strategies using a simulation model that included required nutrients per kilogram of DMI, DIM, test-day milk, dairy merit, and merit weighted by DIM. Grouping systems based on nutrient concentrations were most effective in maximizing return over feed costs, whereas the method based only on test-day milk was least effective.

Sniffen et al. (1993) reviewed research that evaluated optimal group numbers on a dairy farm. Shifting a herd from one to two groups of cows increased FCM production by 1 to 3%. Moving to three groups improved FCM production by up to 2% versus two groups, but shifting to four groups from three only resulted in a 0 to 1% increase in FCM. Overall, marginal return to additional groups declined beyond three. Most researchers have concluded that the milking herd should be divided into three groups with three different diets for optimal efficiency (Grant and Albright, 1997). The actual grouping system selected will depend on herd size, facilities available, and other specifics of the farm situation. The minimum number of groups for a herd would be two: a milking plus a dry cow group. Nutritionally, three feeding or production groups plus two dry cow groups are often preferable. A fresh cow group for the first 3 wk of lactation can serve as a transition from the dry to high-milk production groups.

GROUPING STRATEGIES AND DMI

Feeding Behavior and Feed Intake

Daily feed intake reflects the number of meals consumed daily, the length of each meal, and the rate of eating. By altering the number of daily meals and the average meal size (length × rate of eating), the dairy cow can adjust daily DMI (Grant and Albright, 2000). High-producing dairy cows allowed continuous access to TMR consumed 9 to 14 meals daily, whereas lower-producing cows consumed only 7 to 9 meals per day (Heinrichs and Conrad, 1987). The eating patterns of high-producing cows differ substantially from those of lower producing cows. During the first 5 wk of lactation, dairy cows with the highest eating and ruminating rates had the greatest DMI (Coulon et al., 1987). The importance of eating and ruminating time to the energy budget of the cow becomes clear when it is recognized that between 10 and 30% of the metabolizable energy provided by the feed is used to support these two activities (Susenbeth et al., 1998).

Rate of increase in DMI during early lactation is the primary determinant of energy intake and balance. Dry matter intake increases by approximately 1.5 to 2.5 kg/wk during the first 3 wk of lactation (Bertics et al., 1992; Kertz et al., 1991). Generally, older cows have a more rapid rate of increase in DMI during the first 5 wk postpartum than primiparous cows (Kertz et al., 1991). This difference in feed intake between older and younger cows serves as an argument for separate grouping and management of heifers compared with older cows, at least during the early portion of the lactation.

Grouping of Transition and Primiparous Cows and Feeding Behavior

Dry matter intake is controlled by ruminoreticular fill and physiological mechanisms. However, psychogenic factors can substantially modulate DMI. Psychogenic regulation of intake concerns the behavioral responses of the cow to inhibitory or stimulatory factors in the feed or feeding environment separate from the energy or fill value of the diet (Mertens, 1994). Palatability, social interactions, and learning behavior are integral components of psychogenic modulation of intake. Grouping strategy is a primary component of the cow's environment that can influence DMI as a result of its potential impact on cow comfort, competition for feed, water, and other resources, and herd health.

When practical, heifers within several weeks of parturition should be grouped separately and adapted to their early postpartum environment as reviewed by Grant and Albright (1995). Cows that experience abrupt environmental and social changes during the periparturient period often exhibit aberrant feeding behavior and are more susceptible to metabolic disorders (Bazeley and Pinsent, 1984). First-lactation heifers being introduced to new herdmates and milking facilities require careful management. A successful transition program, from 2 to 3 wk prepartum to 3 to 4 wk postpartum, may involve bringing heifers into the low-milk producing group approximately 3 wk before parturition. For 1 wk, heifers pass through the milking parlor to become accustomed to the parlor environment, free stalls, and concrete lots (Grant and Albright, 1995).

Dry matter intake declines by approximately 30% during the last 7 to 10 d of pregnancy (Bertics et al., 1992). Accordingly, a separate diet should be formulated for this group of cows that contains higher nutrient density. Sniffen (1991) pointed out that DMI capacity of a primiparous heifer within 2 wk of parturition is less on a BW basis than that for an older cow. Consequently, primiparous heifers may benefit from being fed separately before parturition.

To reduce competition from stronger cows, some researchers have recommended a fresh cow group from 1 to 3 wk postpartum in which cows would receive essentially the high cow diet, but with higher concentrations of dietary effective fiber to avoid ruminal acidosis and associated reductions in DMI (Sniffen, 1991).

Due to constraints of limited cattle numbers and facilities at most research farms, few data exist regarding the interaction between group size and individual DMI. Data from lambs, however, indicate that as number of lambs per pen increased, feed consumption per visit to a feeding station increased linearly. However, total feed consumption was greatest for an intermediate number of lambs per group (Jenkins and Leymaster, 1987). One possible explanation for these results could be that social facilitation increased feeding activity initially, and then excessive competition caused a subsequent decline in feed intake (Grant and Albright, 1995). Despite the substantial time, herd, and facility commitments necessary for this type of research using dairy cattle, only this type of research will allow development of grouping strategies that optimize DMI from the transition period to later stages of lactation and the dry period.

Lactating primiparous cows can benefit from separate grouping. Heifers have greater growth requirements, smaller body size, greater persistency of lactation, and frequently a lower position in the group's dominance hierarchy. Phelps (1992) reported the effect of separating smaller, primiparous heifers from larger mature cows. When separated, primiparous cows produced significantly more milk. Competition with older cows resulted in less DMI and milk production compared with primiparous cows fed separately. The difference in performance was proportional to the difference in body size between young and mature cows.

When heifers were separated from older cows, eating time increased by 11.4%, meals per day increased by 8.5%, silage DMI increased by 11.8%, lying time increased by 8.8%, and lying periods increased by 19% per day (Table 1; Konggaard and Krohn, 1978; cited in Grant and Albright, 2000). The system of separately grouping primiparous cows is most commonly found on larger dairies, although the benefits of higher DMI would presumably be apparent on any size farm, particularly where there is excessive competition for feed, water, and other resources. In practice, many producers keep their heifers in the same feeding group throughout the entire lactation.

GROUPING, SOCIAL DOMINANCE, AND COMPETITION FOR FEED

As already mentioned, when dairy cows are grouped, social behavior modifies DMI and productivity. Dairy cows fed in groups are apt to be less fearful and more contented,

Table 1. Performance of primiparous cows when grouped separately from multiparous cows[1]

Item	Cows mixed together	Heifers separate
Eating time, min/d	184	205
Meals per day	5.9	6.4
Concentrate intake, kg/d	10.1	11.6
Silage DMI, kg/d	7.7	8.6
Lying time, min/d	424	461
Lying periods per day	5.3	6.3
Milk production, kg in 130 d	2,388	2,595
Milk fat, %	3.92	3.97

[1]Data from Konggaard and Krohn (1978) as cited in Grant and Albright (2000).

healthy, and more productive (Albright and Arave, 1997). So, the common practice of feeding and milking cows in groups has a sound psychological basis. Efforts are needed to reduce competition within a group for feed, water, stalls, and shade; cow density, cow space, and distribution of feed are closely related issues (Fraser, 1995). On the other hand, when one cow eats, another is stimulated to eat as well, whether she is hungry or not, a behavior termed social facilitation (Curtis and Houpt, 1983). Thus, when cows eat in groups, they consume more feed than when they are fed separately.

Dairy cattle are social animals and readily form dominance hierarchies, particularly at the feedbunk (Friend and Polan, 1974; Grant and Albright, 1995). A dairy cow newly moved into an existing group of cows must quickly find her ranking in the group to maximize DMI, particularly if the cow is in early lactation. Social dominance correlates strongly with age, body size, and seniority in the herd, and plays a pivotal role in any existing, or newly formed, group of dairy cows (Dickson et al., 1970). Social hierarchies and competition for feed affect feeding behavior. A highly competitive time period at the feedbunk or manger coincides with return of cows from milking and when fresh feed is delivered (Friend and Polan, 1974). Early research with small groups of cows indicated that the maximum effect of dominance hierarchies and competition lasted for 30 to 45 min after delivery of fresh feed (Friend et al., 1977). These observations indicated that, relative to group size, bunk space must not be limited, or that feed availability not be limited to avoid reductions in DMI for the more submissive cows.

Cows in the early postpartum period would be particularly vulnerable to excessive competition precipitated by improper grouping. These cows are fatigued, with weakened hind limbs (Sanders, 1990). If forced to compete for feed and water, they can be easily injured or suffer reductions in feed intake. Cows in estrus and dominant cows in the group may prey on vulnerable transition cows (Grant and Albright, 1995). A field report from the Miner Research Institute, in Chazy, New York (Andrew and Emmerich, 1997), indicated that forming a new group comprised of cows ready to leave the fresh-cow group, but not ready for the competition of the high-cow group, resulted in a substantial increase in DMI and milk production. Although this was an observation without a control group from their dairy herd, it does reinforce the potential impact that grouping and stress during early lactation may have on feed intake, productivity, and health.

Table 2. Bunk space and DMI of lactating dairy cows.[1]

Bunk space	Effect on DMI
<0.20 m	Reduced eating time and DMI
0.20–0.51 m	Increased competition with variable effect on DMI
>0.51–0.61 m	No measurable effect on DMI

[1]Data summarized from Albright (1993), Friend and Polan (1974), Friend et al. (1977), Manson and Appleby (1990), and Menzi and Chase (1994).

Group feeding of cattle inevitably results in some degree of competition for feed. Even with unlimited access to feed, cattle interact in ways that may give some individuals an advantage over others in the group (Olofsson, 1999). When a competitive situation exists at the feedbunk, dominant cows typically spend more total time eating than cows of lower social rank, resulting in greater DMI. Recently, Swedish researchers (Olofsson, 1999) evaluated the effect of increasing competition per TMR feeding station from one to four cows under conditions of unlimited feed. As competition per feeder increased, cows exhibited shorter average eating times and accelerated eating rates. Similarly, visits to the feeding station increased in direct proportion to greater aggression during feeding. However, DMI was unchanged. In contrast, when cows were offered limited quantities of feed, dominant cows consumed 14% more feed than submissive cows. This divergence increased to 23% as competition increased from one to three cows per feeding station. Therefore, under conditions of limited feed availability, competition escalated, and DMI of submissive cows suffered.

The correlation between dominance, competition for feed, and performance is most pronounced in situations in which limited feeding space makes feed a defensible resource (Fraser, 1995). Fraser (1995) presented data with fish that showed that in small groups the dominant individuals can monopolize food resources to the point of reducing the weight gain of peers in the group. In large groups, there were so many challengers that the dominant individuals stopped trying to maintain control of the food resource and little aggression was observed. However, with intermediate-sized groups, the dominant individuals attempted to monopolize the food, but there were sufficient challenges that aggression continued unresolved. Clearly, caution is needed to extrapolate data from fish to cattle, but these data illustrate the complex relationships among dominance, group size, and competition. Similar research is needed with dairy cattle, particularly in on-farm settings where cows must compete with peers in their group for feed and other resources.

Critical Feedbunk Space, Feeding Behavior, and Group Size

When dairy cows are fed at a feedbunk or manger, the critical length of bunk space per cow, below which excessive competition occurs, varies with group size and the amount and availability of feed. Several early reports established that little change occurs in feeding behavior when feedbunk space was reduced from 0.61 to 0.31 m per cow. A reduction in bunk space from 0.49 to 0.09 m per cow to increase competitiveness strengthened the correlation between DMI and the dominance value of the individual cow. Albright (1993) postulated that a gradual reduction in bunk or manger space for an established group of cows may be better accepted than adaptation of a new group to limited manger space.

Early research intensively evaluated small groups of cows (50 to 60 or fewer) at low to moderate levels of milk production. Application of results to many modern dairies requires observation of cows in large group sizes (70 or more cows) at high milk production levels (40 kg per cow daily or more), with high DMI (23 kg per cow daily or more). The traditional recommendation of 0.61 linear meters of bunk space per cow is the minimal amount of space needed for all cows to eat at one time. The advent of TMR and proper feedbunk management raises questions about the adequacy of this recommendation. Table 2 summarizes the observed relationships among bunk space, feeding activity, and DMI as reported in the scientific literature and on-farm research trials.

Menzi and Chase (1994) conducted a field trial using two commercial herds in central New York. Both herds had rolling herd averages of >10,500 kg of milk yearly, milked three times daily, used 6-row free-stall housing, fed TMR two or three times daily, with 88 to 90 cows per group. Linear bunk space per cow was 0.37 to 0.40 m. Cows produced approximately 40 kg of milk daily with a daily DMI of 23.6 to 24.5 kg per day. On each farm, the groups of cows observed were those with the highest feed intake and milk production, and, consequently, these cows should have exerted the greatest feeding pressure on the bunk. In these herds, cows increased bunk usage after feeding, when feed was pushed up, or when returning from the parlor. Feed bunk management that provided fresh feed over a 24-h period, within reach of the cow, promoted numerous small meals throughout the day.

Accessibility of feed may be more important than the actual amount of nutrients provided, within reason (Albright, 1993; Grant and Albright, 1995). Cow space, cow density, and distribution of feed and watering facilities all influence DMI. Feed intake and milk production will generally improve when cows are allowed access to feed when they want to eat. Feed restriction can occur under a number of conditions. Aside from simply providing inadequate amounts of feed daily, other common, but less obvious, causes include long time spent in holding area, long time in exercise lot without access to feed and water, unstable, highly fermented silage, poor ventilation, excessive heat and humidity, slippery floors, inadequate or poorly maintained free stalls or comfort stalls, rough mangers, and overcrowding that results in inadequate passageway, stall, or bunk space.

In addition to restriction of feed consumption, water intake cannot be ignored. Recent research (Steiger Burgos et al., 1999) evaluated the impact of a 75% restriction in water intake for 8 d. This degree of water restriction resulted in an 11.3% decrease in 24-h feed intake, a 53% reduction in the size of the first meal every day, and a 31% increase in the number of meals per 24 h.

Based on their on-farm observations, Menzi and Chase (1994) concluded that 0.37 to 0.40 m of bunk space per cow did not necessarily restrict DMI under conditions where cow density did not limit access to the feed. There were few periods of full bunk use during a 24-h period. Although current recommendations for linear feedbunk space are 0.61 to 0.76 m per cow, research results and on-farm observations of high-producing herds with large group sizes indicate that 0.2 m per cow is near the critical bunk space. One should consider, however, the difference between minimum bunk space that can be tolerated in existing facilities with excellent management and desired bunk space in newly designed facilities (Grant and

Albright, 1995). Barns tend to become overcrowded with time, and designing a barn with marginally acceptable bunk space may not be advisable. The actual optimum bunk space will be a function of feed availability throughout 24 h, relative to when cows want to eat, and the degree of crowding and competition placed on the cows by grouping strategy.

GROUP SIZE IN LARGE DAIRY HERDS

Traditionally, dairy cows have been managed in relatively small groups in lots or corrals (40 to 100 cows). Improvements in milking and feeding systems have allowed group sizes to increase up to 200 or more cows. It is not known if a breakdown in the social structure of the herd occurs when groups become too large. Traditional thinking has been that smaller groups help to reduce stress on cows, maintain social structure of the group, allow for better traffic patterns, and increase effectiveness of feeding and breeding programs. Even if social structure weakens with large groups, does it have a significant impact on cow behavior, comfort, and DMI (Grant and Albright, 2000)?

Albright (unpublished data, 1995; FASS, 1999) observed various group sizes ranging from small (50 to 99), to medium (100 to 150; 150 to 199), and large (200 or more) on commercial dairies in Arizona, New Mexico, and Texas. Cows within a group were scanned for feeding and other behavioral activities each hour from 4 a.m. to 7 p.m. This research indicated that there was not a problem with variation in size of group per se. With small to large groups, there were no significant differences in behavioral traits associated with feeding spaces of 0.61, 0.67, or 0.76 m/cow, feeding 2 to 8 times per day, or the number of headlocks per cow. A number of daily management decisions in certain herds or groups, such as overcrowding with insufficient headlocks or manger space, played a significant role in determining overall cow well-being. For example, with 120 headlocks and 150 cows trying to feed, there were 12 agonistic encounters (fights) per minute following feed delivery. One hour later, there were eight fights per minute. Irregular or infrequent feeding, and excessive walking to and from the milking parlor also appeared to have a substantial negative effect on cow behavior and well-being. Even with larger group sizes, typical behavior patterns were observed for social facilitation, leadership-followership, and congregating at the nearest gate to the milking parlor.

At the time of this study (1995), the largest known group size in Arizona, New Mexico, or Texas was 260 cows. Five years later, at the Texas location there are now over 320 cows in a group. With dairies currently being planned or in operation throughout the United States with 400 or more cows in a group, future research should evaluate the effects of these larger systems on productivity, behavior, animal well-being, and farm profitability, as well as public opinion (Albright, 2000).

Group Size, Density, and Cow Behavior

Social dominance is observed in cows when certain individuals initiate and win encounters. These encounters are most frequently head-to-head attacks (60%), followed by attack in the neck region (~10%), with attacks on the side or flank regions being least frequent (Albright, 1978). In a group of a size that allows adequate opportunity for social interaction, the dominance hierarchy can be so stable that a single day's observations can determine the order. French researchers in the 1970s (Bouissou, 1970) found that establishment of dominance-submissive relationships is extremely rapid; about half of the relationships were determined during the first hour. With 20 groups of four previously unacquainted heifers, establishment of dominance-submissive relationships took place without fighting and even without physical contact between animals, although 35% of relationships were determined after a fight. Despite the rapidity of establishment of these dominance hierarchies, the relationships were very stable, and only about 4% of the relationships were reversed.

Bouissou's research was conducted with horned animals. It has been suggested (Albright and Arave, 1997; Albright, 2000) that a more tolerant dehorned cow has evolved through genetics and management than the horned cows of the past. In small groups of 30 horned Guernseys or Holsteins in large dirt lots, cows fighting for dominance was much more common in large herds 50 yr ago. Thus, today's dehorned cows appear to be more compatible and less combative. With self-locking stanchions (head gates) and mixer wagons delivering large quantities of TMR there is less competition at the feed manger (Albright, 2000).

Conventional wisdom holds that cows fight to establish dominance, and that they no longer fight when dominance has been established, that dominance regulates priority of access to resources, and that group size should not exceed the number of cows that an individual can recognize to maintain a stable dominance hierarchy. Realistically, there may well be continued and fluctuating levels of fighting (Fraser, 1995). Research with pigs indicates that some individuals within a group thrive not by winning fights, but by not participating in them (Mendl et al., 1992). Research is needed to determine if the same concept holds true for dairy cattle.

For group sizes greater than 100 cows, the ability to recognize all group mates may diminish. In larger groups, small subgroups may form, as in poultry flocks (Albright, 1978). Within a large group, however, cows should be given the opportunity to know one another. Some behaviorists have suggested that stress could arise due to failure to establish a stable dominance hierarchy. A question deserving further investigation is the relative importance, in groups of 100 to 200 or more cows, of subgroups versus interaction with the entire group. The relative importance would be a function of the "living" space allowed per group, and degree of competition for feed, head gates, water, and free stalls.

The optimal size of a group of cows on any dairy, from a behavioral perspective, will be a function of 1) competition for space in the barn, lot, or pasture, 2) competition for feed and water, 3) availability of comfortable, usable free stalls, 4) space in holding areas before and after milking, and 5) time spent in holding area and away from stalls, feed, water, and shade.

For instance, in field observations of 10 dairy herds in Nebraska during the summer of 1997 (Grant, 1997, unpublished data), in most cases farms with the highest DMI and productivity had alleys of sufficient width so that two cows could comfortably walk in opposite directions behind the row of cows standing and eating at the feed line. With insufficient space, either from design or overcrowding a group, normal movement of cows in the alley behind the feed manger disrupted eating activity, precipitated fights, and interfered with intense, focused feeding activity. Many free-stall barns designed today provide for approximately 12.2 to 16.8 m^2 of floor space per cow, exclusive of free stall and drinking areas. The alley between the feeding line and the first row of free stalls should be 4.3 m wide to allow comfortable cow movement and avoid interference with aggressive eating activity (Smith et al., 2000).

With large groups of dairy cows, several important questions can be raised relative to feeding behavior and group interactions. First, do cows have preferred locations along a feed alley or do they exhibit no preference? Related to this issue, is feed availability equal along the entire length of the feed alley? If it is not, what is the effect on competition for feed? It may be that simply measuring the amount of feed refused daily for a group or pen is a poor indicator of feed availability to every cow in a group, even if feed has been pushed up frequently.

Overcrowding and Feeding Behavior

What effect do "living space" and overcrowding have on a cow's well-being as measured by DMI, milk production, and health? A Purdue University study (Arave et al., 1974) crowded small groups of familiar cows (17 per group) from 30.5 m^2 of lot space down to 7.6 m^2 per cow. There were no differences in DMI, milk production, milk leucocytes, or plasma cortisol. There were statistically fewer encounters, and less total activity, among the crowded cows. When encounters did occur, they were most often between the most dominant and most submissive cows. Often, an encounter begins a chain reaction of encounters, in which a dominant cow butts another out of her way at the feed bunk, and this cow quickly finds a group mate that she can dominate, and so on (Grant and Albright, 2000). The relevance of these data to high-producing cows in larger groups is open to debate. Some researchers have suggested that crowding may be less harmful in small groups where no strangers are encountered. As groups become larger, it is more difficult for cows to recognize group mates and their status in the social order of that group. Researchers in New Zealand with up to 800 cows or more in a group (cited in Albright, 1978) have found that leucocytes increased significantly when cows with previous mammary infections were under stress from overcrowding. Another practical consideration, aside from behavior and any potential impact on feeding activity, is the problem of keeping cows clean with reduced space per group. Apparently, cows with a previous history of mastitis are particularly susceptible to overcrowding stress. Adequate space near the feedbunk and water availability is critical.

Recently, Batchelder (2000) reported on the interaction of head gates or no head gates with 0 or 30% overcrowding of free stalls and feeding space. Animals were observed every 15 min for 24 h following an adaptation period of 3.5 wk. Use of head gates resulted in a 3 to 6% reduction in DMI at 0 or 30% overcrowding, with a negative effect of overcrowding as well. The percentage of cows eating postmilking ranged from 45 to 66%, with no overcrowding down to only 30 to 38% for overcrowded cows. The percentage of cows that consumed meals at feeding time was 32 to 43% for no overcrowding, but only 21 to 27% for overcrowded cows. Importantly, overcrowded cows preferred lying in free stalls over eating after exiting the parlor. These overcrowded cows also spent more time standing in the alley waiting to lie down than they did eating. The percentage of cows ruminating in the overcrowded groups averaged 28% (with a high of 32%), whereas cows that were not overcrowded averaged 37% (with a high of 55%). These results raise interesting questions regarding the impact of the cow's social and physical environment on rumination, independent of the inherent effective fiber content of the diet.

The use of headlocks as a management tool for use with grouped dairy cows has been evaluated by Bolinger et al. (1997), and the reader is referred to this paper for more detailed information. These researchers reviewed the impact of headlocks on cow behavior and measured the impact of extended time spent in headlocks on cow productivity, feeding and other behavior. In this study, 64 Holstein cows were restrained in self-locking stanchions for approximately 4 h/d. Milk production, SCS, and total daily feed intake were not affected by the restraint. Behaviorally, cows that were locked up spent significantly more time lying down after release from restraint. For cows that were locked in stanchions, eating frequency over 24 h was significantly reduced, but DMI was unaffected. Grooming was significantly increased during all times that cows were not locked up, and was considered to be a behavioral need. Grooming was also one of the first behaviors performed following release. Acts of aggression were elevated during all periods following restraint. Although the proper use of self-locking stanchions for restraint does not seem to substantially affect the overall well-being of the cow, there appears to be some potential to impact feeding and ruminating behavior adversely.

MOVING COWS BETWEEN GROUPS

When deciding to move cows from one group to another, one needs to consider the labor, nutritional, and social implications of moving cows versus the increased feed efficiency resulting from grouping cows with similar nutritional and management requirements. Confirmed pregnancy, level of milk production, and BCS should be major criteria for the decision to move cows from one group to another. The number of aggressive encounters following movement from one group to another can be reduced by housing cows in adjacent lots or groups, permitting some limited close proximity and physical contact (Albright and Arave, 1997). In some free-stall barn designs, this would be possible, for instance, if the fresh cow group were adjacent to the high cow group, or if the close-up group were adjacent to the fresh cow group.

Moving larger numbers of cows at one time versus moving only a few results in less fighting and social disruption of the group. Handling procedures are more stressful for an isolated cow, so several cows should be handled or moved at one time. When cows are added to a socially stable group, the entire group may be disrupted through threat, butting, and physical aggression until the added cows have found their place in the social structure of that group. Early research (Schein and Fohrman, 1955) found that about 1 wk was required for the dominance hierarchy to become reestablished and stabilized after new cows were introduced into the group.

A regular routine for moving cows and adequate feeding space for the size of the group are important factors in the success of any grouping and cow movement system. One of the most common concerns among dairy producers is how to avoid reductions in DMI and milk production when cows are shifted from one group to another. When a cow moves from one group to another, she is subjected to both social and nutritional stress. This situation reflects not only the differences in ration formulation between groups, but also the different feeding and milking times for each group.

Social Effects Associated with Shifting Cows Between Groups

Cows are social animals and ranking within a group occurs based on dominance. When cows are moved from one group to another, a new social order for that group must be established. Several studies have been designed to partition the effects of social versus nutritional factors on DMI and milk production associated with regrouping, in which cows but not rations are changed. Generally, studies indicated a 2.5 to 5.0% greater decrease in milk production due to social disturbances compared with control animals that were not regrouped (Albright, 1978).

Konggaard and Krohn (1978; cited in Grant and Albright, 1997) conducted a series of trials to evaluate the effect of social changes with no ration changes. After transfer to a new group, the eating time decreased and number of confrontations increased substantially during the first day. Early lactation cows exhibited the greatest reduction in DMI and milk production. Overall, these research results indicated that the influence of a social change is transitory, which agrees with observations that dominance hierarchy within a group is stable and quickly established (Bouissou, 1970; Albright, 1978). Most observations indicate that the social impacts of regrouping dairy cows last about 3 d, and almost always less than 7 d.

The effect of regrouping appears to be variable, but potentially significant at reducing DMI and milk production. Cows should be moved from one group to another based on milk production level, BCS, age, and generally, following the afternoon or early evening milking the cows should be moved in small groups to minimize social disruption (Albright, 1978). Remember that not only is there social pressure on the cow in her new group, but she may well have different feed, a new milker, and a different milking time.

CONCLUSIONS

Feeding is normally the predominant behavior in dairy cattle; rumination can take precedence only when it has been abnormally restricted. Dairy cattle consume feed efficiently whether at a feedbunk or grazing. However, grouping strategy will impact the cow's ability to express aggressive eating behavior. Within a group of cattle, social hierarchy, competition for feed, water, space, and feed availability will determine feeding behavior and DMI. Feed accessibility to every cow within the group when she desires to eat may be the most important factor influencing the attainment of maximum DMI, productivity, and well-being.

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